# SIMULATION OF PACKING AREA THROUGHPUTS UNDER DWASP

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Cameron Station,
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This report details the results of a simulation of the Defense Logistics Agency Standard Warehousing and Shipping Automated System (DWASP) Increment II for Defense Depot Ogden, Utah (DDOU). The system under study includes the printing of the Issue/Release Receipt Document (IRRD), packing, and offering to transportation for bin operations. In addition to these functions, all associated hardware such as conveyors, automatic sealers, bar code readers, and printers are modeled as well. The analysis indicates that there were two major areas for concern--the multiline packing and the single line offer stations. In the packing area, there was an imbalance in the work among the packers. Specific recommendations in packing include alteration of the current scheme for assigning work to multiline packers and placing a cap on the maximum size shipping unit. In the offer area the original configuration could not accomplish the required throughput. The addition of another diversion belt and splitting up the offer function into three components performed in different areas resolved the problem.

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DLA-LO
June 1988

# FOREWORD

This report details the results of a simulation of the DLA Standard Warehousing and Shipping Automated System (DWASP) Increment II for Defense Depot Ogden, Utah (DDOU). The system under study includes the printing of the Issue/Release Receipt Document (IRRD), packing, and offering to transportation for bin operations. In addition to these functions, all associated hardware such as conveyors, automatic sealers, bar code readers, and printers are modeled as well.

The analysis indicates that there were two major areas for concern--the multiline packing and the single line offer stations. In the packing area, there was an imbalance in the work among the packers. Specific recommendations in packing include alteration of the current scheme for assigning work to multiline packers and placing a cap on the maximum size shipping unit. In the offer area the original configuration could not accomplish the required throughput. The addition of another diversion belt and splitting up the offer function into three components performed in different areas resolved the problem.

for [signature], Col, USAF
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Office of Policy and Plans

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# I. INTRODUCTION

## A. Background

Based on a DoD directive to implement Logistics Applications of Automated Marking and Reading Symbols (LOGMARS) for all logistics applications that could significantly benefit from use of automated symbology (e.g., bar-coding), DLA began a program of upgrading its automated information systems in the depots to use this new technology and improve performance. Previously a batch processing information and control system called Mechanization of Warehouse and Shipment Processing (MOWASP) served as the software workhorse for the day-to-day operations in the DLA depots. The new system, DLA Standard Warehousing and Shipping Automated System (DWASP), was to take advantage of these technological advances to provide for a more efficient and effective operation.

DLA decided to implement DWASP in five increments:

I. Receiving
II. LOGMARS Shipping Documentation
III. Issue and Transportation
IV. Warehouse Stock Management
V. Set Assembly/Disassembly

Implementation of DWASP receiving began in 1985 and was completed in 1986. For increment II, the packing and offer station area, Defense Depot Ogden, Utah (DDOU) was the first implementation site. In order to fully capitalize on the use of bar coding technology, the design called for concurrent improvements in the materiel handling equipment such as tilt tray sorters, automated sealing and strapping devices, bar code scanners, etc. DDOU engineers worked with the Depot Operations Support Office (DOSO) in designing the system.

B. Problem Statement and Study Objectives. The DLA Operations Research and Economic Analysis Office (DLA-LO) was tasked to perform a computer simulation of the proposed design for DDOU bin packing and offer. The objective of the simulation was to determine if the design could meet the goal throughput and to make recommendations on system improvements.

C. Scope. This study was limited to the design of the bin packing area of DDOU. The functions represented in the simulation included the attachment of the Issue Release/Receipt Document (IRRD), packing, sealing and strapping, and offering to transportation. Furthermore, even though later increments of DWASP would change operations to some extent in the offer station area we limited our look to increment II since the exact nature and timing of those changes were not clear.

## II. CONCLUSIONS

The study yielded the following conclusions:

1. The IRRD mezzanine and the single line packing worked smoothly under both goal and current workload scenarios. However, manpower and equipment utilizations were relatively low in these areas when all stations were manned.

2. The current scheme for the assignment of shipping units to packing stations caused significant backlogs in some of the packing chutes. A revision that put a cap on the maximum shipping unit size and alternated daily the chute obtaining the largest shipping units resolved the problem.

3. Significant queueing problems occurred in the single line offer station area for both the current and goal workload scenarios. The time waiting for computer response for label printing and the time to perform special labelling represented major portions of the total offer processing time. Placement of scan stations prior to offer would eliminate the wait time. This combined with allocating the special labelling function to the transportation area and the addition of a divert lane from single to multiline offer overcame this problem.

## III. RECOMMENDATIONS

The following recommendations are made:

1. Add a divert conveyor prior to the single line offer to provide the flexibility of having the multiline offer area assume some of single line work in peak periods.

2. Split the current offer functions - place scan stations prior to offer and let stations in the transportation area do specialized labelling for weapons systems pouches, small parcel air, number insured, etc.

3. Revise the scheme for assigning shipping units to packing stations. Instead of always having the same chute receive the largest shipping units each day for each batch, alternate the chute so that a better workload balance can be achieved. To further level out the work in the first eight multipack chutes, place a control in the system that puts a cap on the maximum shipping unit size. The value of this parameter should be a local decision. But under the assumption that the packing time standard used in our work is valid, a value of 150 is recommended.

## IV. METHODOLOGY

### A. General Methodology

The general approach in this study was to develop a SLAM simulation model of the packing and offer system. Although simulation was necessary to examine the dynamics of the system, a flow rate analysis based on expected

value calculations was first performed to assist in detecting any obvious problems and to aid in model verification. The flow rate analysis used the average processing times and workload arrival rates for each station to project resource utilization, queue lengths, and completion times. Next, the design was modelled and solutions to problem areas were investigated with the simulation. The primary measure of effectiveness for deciding among alternatives was the throughput for each of the functional sections. Secondary measures were resource utilization and queue size.

The model design was different than that used in the Mechanicsburg Integrated Materiel Complex (IMC) simulation (DLA-LO Project 6018) and the DICOMSS simulation (DLA-LO Project 6004) in that workload was allowed to be carried over from one day to another. For the previous simulations the main measure of effectiveness was the time to finish a complete day's work. The carryover approach is more realistic in terms of the actual operation of the system. System managers employ carryover to avoid extreme staggering of section starting times by allowing workload to build up at the end of the previous day.

B. Model Description. A schematic diagram of the packing and offer station area is presented in Figure 1. There are four main functional areas depicted - the IRRD mezzanine, single line packing, multiline packing and the offer stations. Each of these is discussed below after a brief overview of the picking operation.

1. Picking and Packing Assignment. Customer requisitions that are to be picked for a given day are organized into several batches or cycles of stock selection. DDOU uses four batches of picks, one for Issue Priority Group (IPG) 1, one for IPG 2, and two for IPG 3. All the requisitions within an IPG group that are destined to be packed for a given customer are consolidated into a unit called a shipping unit. The shipping units within each batch are assigned to a specific packing chute at the beginning of the day. The scheme for assignment that was used in the initial model runs was as follows. Within a given batch, the largest shipping unit is assigned to chute 1, next largest to chute 2, etc. When chute 49 is assigned a shipping unit, the scheme doubles back until it exhausts all shipping units. However, since the first chutes are assigned the largest size shipping unit, the first six are dedicated to only one shipping unit per batch.

2. IRRD Mezzanine

Once an item is picked for a customer, a pick ticket is attached that contains a bar code called an Operational Control Number (OCN) (Figure 2). This number identifies it to the system and is used to determine which shipping unit it is a part of, which packing chute it is ultimately to travel to, and what information is to accompany the item. Once they are picked, the items, usually in small bags or cartons, are brought to the packing area and placed on the input conveyor. They are oriented with the OCN upward so that it can be scanned by bar code readers along the way.

Figure 1

SCHEMATIC DIAGRAM OF PACKING AND OFFER STATION AREA

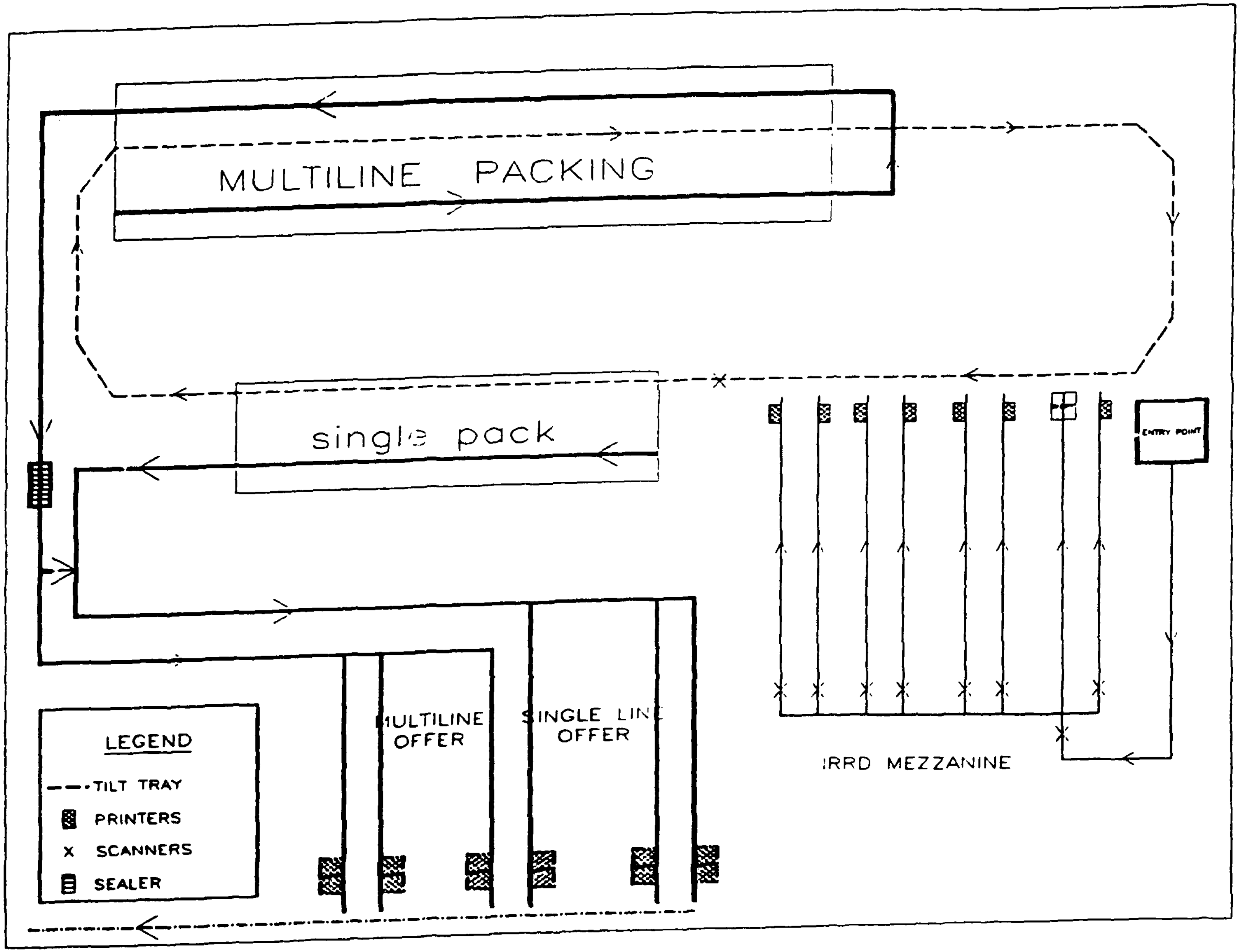

Figure 2

PICKING TICKET WITH BAR CODE

```
156-07-67-AA  5310-00-061-7326
155-03-18-DA    NUT STL
                 1  HD  CC-A
                 UP 00003.71
 PRES & PACK C/C
                  * IPG 3 *
DATE  PDT
8013  014      UNIT PACK 00000
               LI QTY 00001
0131728-8
0016 OF 0028
  FRT

SHIP EXACT QTY

NO APPLICABLE CODE
NO SPECIAL CODE APPL

   SU-S16     TU-S16
BN-13     RESTART 00914      L        04YS1
```

```
156-08-20-JA  5310-00-962-5864
                WSHR ALM
                20  EA  CC-A
                 UP 00000.46
 PRES & PACK C/C
                  * IPG 3 *
DATE  PDT
8013  014      UNIT PACK 00001
               LI QTY 00000
0132507-8
0031 OF 0056
  FRT

NO APPLICABLE CODE
NO SPECIAL CODE APPL

   SU-S16     TU-H6
BN-13     RESTART 00915      L        050V2
```

```
156-08-22-CA  5935-00-817-4602
                CONNECTOR
                 3  EA  CC-A
                 UP 00001.28
 PRES & PACK C/C
                  * IPG 3 *
DATE  PDT
8013  014      UNIT PACK 00001
               LI QTY 00000
0131728-8
0017 OF 0028
  FRT

SHIP EXACT QTY

NO APPLICABLE CODE
NO SPECIAL CODE APPL

   SU-S16     TU-S16
BN-13     RESTART 00916      L        04YS2
```

```
156-08-29-GA  5340-00-699-8463
                CLIP STL
                 1  EA  CC-A
                 UP 00000.30
 PRES & PACK C/C
                  * IPG 3 *
DATE  PDT
8013  014      UNIT PACK 00001
               LI QTY 00000
0132798-4
0085 OF 0147
  FRT

NO APPLICABLE CODE
NO SPECIAL CODE APPL

   SU-S16     TU-R3
BN-13     RESTART 00917      L        0511X
```

The conveyor brings the item up to the IRRD mezzanine and the OCN is scanned. If for some reason the OCN cannot be scanned, the item is diverted down the exception processing lane and processed manually. Otherwise, it is diverted down one of the IRRD lanes and scanned again. At this point a signal is sent to the printer at the end of the lane to print the IRRD. The IRRD (Figure 3) contains information on the name, quantity, etc. of the item. When the item reaches the actual IRRD station the operator removes the IRRD from the printer, matches the IRRD with the item, staples the IRRD onto the item and places it on the tilt tray sorter next to him/her to be taken away to packing.

3. Single Line Pack Stations. If the item is the only item in the shipping unit, the tilt tray sorter will take it to one of the 13 single line packing stations. There the item is packed and then put on a takeaway conveyor which transports it to the offer area.

4. Multiline Pack Stations

Items that are part of a multiline shipping unit are dropped off at 1 of the 50 multiline packing stations. The fiftieth station serves as an exception station that processes items that were not dropped at any of the previous stations for some mechanical or bar code read fault.

At a station, the packer uses the DWASP system to identify which container the item is to go into and whether the shipping unit is complete or not. A bar code label OCN is placed on each carton at the packing area to identify the shipping unit contained in the carton. Once the shipping unit is complete the packer places the cartons on the takeaway conveyor that transports them to the automatic sealer and ultimately to the offer area.

Not all stations are manned at all times. The initial scheme for manning the chutes was to place 1 packer in each of the first 18 chutes and 1 packer per 6 chutes for the remainder. These latter packers would jockey from chute to chute on an as-needed basis. The reason for the large number of chutes is to assist in shipping unit separation. A chute can contain multiple shipping units at a time. If the number of shipping units in a given chute is excessive, the packer spends a significant amount of time keeping the units separated. This confusion also increases the risk of an item being placed in the wrong carton.

5. Offer Stations

There are two banks of three offer stations each. One bank services mainly the single line shipping units and the other the multiline. The functions performed are the same. The operator scans the bar code OCN on the package, enters the offer data (weight, cube, transportation mode, etc.) and verifies it on the CRT screen. Then the computer sends information to the printer at the station to begin printing the appropriate shipping documentation. Depending on the activity level of the computer there may

Figure 3

ISSUE RELEASE/RECEIPT DOCUMENT

DD FORM 1348-1A, JUN 86 ISSUE RELEASE/RECEIPT DOCUMENT

| DOC IDENT | RI FROM | M & S | UNIT ISS | QUANTITY | SER | SUPPLEMENTARY ADDRESS | SIG | FUND | DISTRIBUTION | PROJECT | PRI | REQ'D DEL DATE | ADV | RI | O/P | COND | MGT | UNIT PRICE DOLLARS | CTS | 1 TOTAL PRICE DOLLARS | CTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A5ASUGK | PG00001 | | | | | | | | | | A6C 01 | 12 | | 2DS9GAA | | | | 00004 | 13 | 000004 | 13 |

| 2 SHIP FROM | 3 SHIP TO | 4 MARK FOR |
|---|---|---|
| SW3400 | 678822 | |

| 5 DOC DATE | 6 NMFC | 7 FRT RATE | 8 TYPE CARGO | 9 PS |
|---|---|---|---|---|
| 8025 | 179060 B | LT0085.0 | 292 | U |

| 10 QTY REC'D | 11 UP | 12 UNIT WEIGHT | 13 UNIT CUBE | 14 UFC | 15 SL |
|---|---|---|---|---|---|
| | 001 | 00000.00 | 000.00 | | 0 |

16 FREIGHT CLASSIFICATION NOMENCLATURE

17 ITEM NOMENCLATURE
PINRECORD

| 18 TY CONT | 19 NO CONT | 20 TOTAL WEIGHT | 21 TOTAL CUBE |
|---|---|---|---|
| | | | |

| 22 RECEIVED BY | 23 DATE RECEIVED |
|---|---|
| | |

24 DOCUMENT NUMBER & SUFFIX (30-44): FB466180160226

25 NATIONAL STOCK NO & ADD (8-22): 6685011121919

26 RIC (4-6) UI (23-24) QTY (25-29) CON CODE (71) COG (55-56) UP (74-80): S9GPG00001A010000413

27 ADDITIONAL DATA

0222747000100-9

OCN-06YMF

004

FORM APPROVED, OMB NO 0704-0188

DD FORM 1348-1A, JUN 86 ISSUE RELEASE/RECEIPT DOCUMENT

| DOC IDENT | RI FROM | M & S | UNIT ISS | QUANTITY | SER | SUPPLEMENTARY ADDRESS | SIG | FUND | DISTRIBUTION | PROJECT | PRI | REQ'D DEL DATE | ADV | RI | O/P | COND | MGT | UNIT PRICE DOLLARS | CTS | 1 TOTAL PRICE DOLLARS | CTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A5ASUGK | PG00001 | | | | | | | | | | A6C 01 | 12 | | 2DS9GAA | | | | 00004 | 13 | 000004 | 13 |

| 2 SHIP FROM | 3 SHIP TO | 4 MARK FOR |
|---|---|---|
| SW3400 | 678822 | |

| 5 DOC DATE | 6 NMFC | 7 FRT RATE | 8 TYPE CARGO | 9 PS |
|---|---|---|---|---|
| 8025 | 179060 B | LT0085.0 | 292 | U |

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|---|---|---|---|---|---|
| | 001 | 00000.00 | 000.00 | | 0 |

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|---|---|
| | |

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25 NATIONAL STOCK NO & ADD (8-22): 6685011121919

26 RIC (4-6) UI (23-24) QTY (25-29) CON CODE (71) COG (55-56) UP (74-80): S9GPG00001A010000413

27 ADDITIONAL DATA

0222747000100-9

OCN-06YMF

004

FORM APPROVED, OMB NO 0704-0188

be a delay prior to initiation of printing the documentation. Note also that the original design has a divert that allows diversion of work from the multiline area to the single line area for peak periods.

Which documents are printed depends on the mode of transportation. The military shipping label (MSL, DD Form 1387) (Figure 4) is printed for all containers. In addition an automated packing list (Figure 5) and a route slip (Figure 6) may also be required for packages going freight. There may also be some additional labelling required based on whether the item is weapon system pouch, number insured, small parcel air, etc. Once all the labelling and documentation are complete, the operator places the packages on the conveyor that takes them to transportation.

### C. Data Development

The data development is broken into three main areas: workload characteristics, equipment characteristics and time standards for the different workstations.

Current data on the workload such as number of single line shipping units, distribution of shipping unit size, number of IPG 1s, 2s, 3s was obtained from DDOU for the period from 20 March 1987 to 28 April 1987. During that timeframe the average number of lines packed in bin operations was 6,521 per day. In the initial analysis, the goal workload for the system was set at 12,225. However, at an interim briefing to the client it was discovered that the goal workload that was provided was in error and was in actuality the goal workload for the entire depot. Subsequently the goal workload for bin operations packing was reduced to 9,169. However the baseline model runs prior to the interim briefing were based on the 12,225 workload.

In order to determine the distribution of the shipping unit sizes for the goal workload it was unreasonable to use the same distribution as for current workload since increases in the number of customers served would be minimal. We employed the same methodology as used in the Mechanicsburg IMC Study (DLA-LO Project 6018) that increased the current distribution by a random factor (from 1 to 2.5) on a shipping unit to shipping unit basis. This placed most of the additional workload into larger shipping units but also allows for some limited growth in total number of shipping units per day over current levels. Details of the data used in the simulation are presented in Appendix A. A summary of the workload is provided in Table 1 for the 12,225 scenario.

Figure 4

MILITARY SHIPPING LABEL

1. TRANSPORTATION CONTROL NUMBER
W26AEK80130356XXX

2. POSTAGE DATA
POSTAGE AND FEES
PAID DEFENSE
LOGISTICS
AGENCY DOD-334

3. FROM
DEFENSE DEPOT OGDEN
OGDEN UTAH SW3400
OFFICIAL BUSINESS PENALTY FOR PRIVATE USE $300

4. TYPE SERVICE
P/P

5. SHIP TO POE 0221599 Z4ZVH
W26HBK CENTRAL RECEIVING POINT FT LEE VA
CRP WHSE T7126
FT LEE VA 23801 5171

6. TRANS PRIORITY
3

7. POD

8. PROJECT

9. ULTIMATE CONSIGNEE / MARK FOR
W26AEK
INSTAL PBO
CRP WHSE T7126
FT LEE VA 23801 5171

10. WT.
00000

11. RDD

12. CUBE
0000.0

13. CHARGES

14. DATE SHIP
88025

15. FMS CASE NUMBER

16. PIECE NUMBER
00001

17. TOTAL PIECES
00001

Figure 5

AUTOMATED PACKING LIST

```
SU-OCN ZOQSX      AUTOMATED PACKING LIST DATE 01.25.88.025 PAGE     1

SU NUMBER                  TCN          TAC   POE POD PROJ
0222747000000   FB466180160175XX S1EE       OTX
TO FB4661 96 BOMB WG                               FROM SW3400
       DYESS AFB TX 79607                               DEFENSE DEPOT OGDEN
                                                        OGDEN, UTAH

NOMEN      QTY  UI SR STOCK NUMBER DOCUMENT NUMBER S-ADD  UN-PRICE  COST

RELAY      00003 EA Z 5945008256538 FB466180160175        00052.31 156.93
PINRECORD  00001 PG Z 6685011121919 FB466180160226        00004.13 004.13
SOLENOIDS  00002 EA   5945006051678 FB466180160348        00001.00 002.00
 CONTAINER 0001          LTL    NMFC
                     0085.0  179060


TOTAL CONTAINERS 00001
```

Figure 6

ROUTE SLIP

```
    88025     L79     DTT = 88025
  SU OCN = ZOQSX   CHECK DIGIT = 9    DEST = 678822   LOCATION:

 0222747               1        4       .6 FB   Z


 PDT = 025    IPC = 3
              TIME = 1412


   MODE          STATUS         HOLD         TAC            COMM

     FB4661 96 BOMB WG
            DYESS AFB TX 79607
```

Table 1

GOAL WORKLOAD CHARACTERISTICS

| | LINES | SU'S | SINGLES | MULTI SU'S | LINES/MULTI |
|---|---|---|---|---|---|
| IPG1 | 1501 | 785 | 675 | 110 | 7.5 |
| IPG2 | 2386 | 848 | 700 | 148 | 11.4 |
| IPG3-DROP 1 | 4727 | 142 | 75 | 68 | 69.0 |
| IPG3-DROP 2 | 3611 | 1403 | 1046 | 357 | 7.2 |
| DAILY TOTAL | 12225 | 3179 | 2496 | 684 | 14.2 |

Equipment characteristics and station processing times were provided by DOSO and are detailed again in Appendix A. The critical ones are presented in Tables 2 and 3. The computer response time in Table 3 is the time from when a scan is made by a bar code reader to the time the computer sends the required information to the printer to begin printing.

Table 2

CRITICAL STATION TIMES

| Station | Average Processing Times |
|---|---|
| IRRD Regular | 10.5 secs/line |
| IRRD Exception | 26.3 secs/line |
| Single Pack | 109.0 secs/line |
| Multi Pack | 65.5 secs/line |
| Offer | 72.0 secs/carton |

Table 3

CRITICAL EQUIPMENT TIMES

| Equipment | Average Processing Time |
|---|---|
| Computer Response | 8.0 secs |
| IRRD Printer | 4.6 secs |
| Automatic Sealer | 11.0 secs |
| MSL Printer | 3.0 secs |
| Route Slip Printer | 8.3 secs |

## V. ANALYSIS

### A. Baseline Results

By baseline we mean the system as designed and using 12,225 items for packing as the goal workload. The expected value calculations revealed some interesting conclusions. Table 4 details the results of those calculations. Note that in the offer station area the expected values included time for the computer response and the documentation print times.

Table 4

BASELINE EXPECTED WORKLOAD

| Section | Hours per Station |
|---|---|
| IRRD Regular | 4.7 |
| IRRD Exception | 6.5 |
| Single Pack | 5.4 |
| Multi Pack | 7.7 |
| Single Offer | 23.3 |
| Multi Offer | 5.7 |

Immediately one sees one and possibly two problem areas. Clearly a major problem exists in the single line offer area for the goal workload. Secondly, there is a possibility of problems in the multiline pack area if only 23 packers are assigned since the average work is 7.7 hours. Considering that there might be difficulties in balancing the workload evenly and also that there may be some slack time between arrivals of items especially from different pick batches, we felt that this might be an area for concern.

This led us to determine if the design in the offer area could meet the current workload. It could not. For the current workload of 6,521, the single line offer stations averaged 12 hours of work per day and the multilines 6.4. Even if another divert was installed to allow a diversion of single line work over to the multiline area, overall there was still 9.2 hours of work per day per station.

Of course, when we ran the simulation under these circumstances for the 12,225 workload, the situation in terms of the queue buildups at the single line offer stations was as anticipated from the expected value analysis. The simulation also revealed another very significant problem--one in balancing the workload for the multiline packing area. Using a 60-day run of the model with the first 15 days as a warmup period, the average work for each of the packers in the multiline area was calculated. Results for the multiline packing area are portrayed in Table 5. Recall that the assignment scheme for packers to chutes for this scenario was 1 packer per chute for the first 18 and 1 per 6 chutes for the remainder.

To resolve this problem we looked at a scheme of adding one more packer, reassigning the number of persons per chute and also daily rotating the chute that gets the largest shipping units. Furthermore, the number of chutes dedicated to the large shipping units was expanded from six to eight. The results for that 60-day scenario are also presented in Table 5. The new assignment scheme was 1 packer per chute for the first 8, 1 packer for 2 chutes for the next 10 chutes, 1 packer per 3 chutes for the next 27 chutes and finally 1 packer per 2 chutes for the remaining chutes.

The workload balance achieved was substantially better. However there were still some problems in chutes 19-45 where each packer services 3 chutes and in the first 8 chutes. In chutes 19-45, the average workload per day is still too high. The addition of 2 floaters in this area resolved the problem and brought the average workload per day down to 7.1 hours per person. In the first 8 chutes, although the average workload per day was within an acceptable range, more than 40 percent of the time a chute received more than 7 hours of work. This was the direct result of a relatively high percentage of large shipping units.

Table 5

AVERAGE DAILY WORKLOAD-MULTILINE PACKERS

| | Original Assignment | | Revised Assignment | |
|---|---|---|---|---|
| Packer | Chute | Hours Work | Chute | Hours Work |
| 1 | 1 | 18.7 | 1 | 6.4 |
| 2 | 2 | 10.0 | 2 | 6.5 |
| 3 | 3 | 7.5 | 3 | 6.7 |
| 4 | 4 | 6.6 | 4 | 6.7 |
| 5 | 5 | 6.4 | 5 | 6.8 |
| 6 | 6 | 5.7 | 6 | 6.4 |
| 7 | 7 | 5.0 | 7 | 6.5 |
| 8 | 8 | 4.6 | 8 | 6.6 |
| 9 | 9 | 4.3 | 9-10 | 7.0 |
| 10 | 10 | 4.1 | 11-12 | 6.6 |
| 11 | 11 | 3.9 | 13-14 | 6.3 |
| 12 | 12 | 3.7 | 15-16 | 6.0 |
| 13 | 13 | 3.5 | 17-18 | 5.9 |
| 14 | 14 | 3.4 | 19-21 | 8.6 |
| 15 | 15 | 3.2 | 22-24 | 8.4 |
| 16 | 16 | 3.1 | 25-27 | 8.4 |
| 17 | 17 | 3.0 | 28-30 | 8.3 |
| 18 | 18 | 2.9 | 31-33 | 8.4 |
| 19 | 19-24 | 16.4 | 34-36 | 8.4 |
| 20 | 25-30 | 14.7 | 37-39 | 8.7 |
| 21 | 31-36 | 13.7 | 40-42 | 9.0 |
| 22 | 37-42 | 13.2 | 43-45 | 9.4 |
| 23 | 43-49 | 15.4 | 46-47 | 6.8 |
| 24 | | N/A | 48-49 | 7.2 |

During an interim briefing to the client, the frequency of large workload in the first eight chutes was deemed unacceptable. In view of the physical setup of the workstations with only one CRT, there is not much advantage to putting two people on a single station when that station becomes greatly backlogged. The idea of placing a cap on the maximum shipping unit size was discussed as a solution to this problem. Suppose the cap was set at 300. This would split a 900 line shipping unit into 300 line units. It was felt that this would not significantly increase the transportation costs since the new units would be consolidated in transportation under DWASP anyway.

The directions that resulted from the interim briefing to the client were:

1. Since there was not enough physical space to add offer stations to accommodate the workload, split the designed offer functions into three: a) initial OCN scan and data entry, b) application of shipping label, route slip, and automated packing list, and c) any additional

labelling for number insured, etc. The question arose as to whether one scan station could serve more than one offer line was to be investigated. The initial idea was to have one scan station placed between each of the two offer lines in order to save on equipment and personnel costs.

2. Add a divert prior to offer that would allow diversion of work from single line offer to multiline offer to assist in balancing the offer workload.

3. Review the goal workload. Ultimately this was factored down from 12,225 to 9,169.

4. Examine the effects of placing a cap on the maximum shipping unit size on the balancing of workload in the multiline packing area.

B. Offer Station Reconfiguration Analysis

The revisions mentioned above formed the guidance for this scenario. The processing times presented in Table 6 were used for each of the stations now performing one of the functions previously done at an offer station.

The first thing we examined was the placement of a cap on the maximum shipping unit size. This was analyzed using the a modified version of the simulation. Since the run time for a 15-day period was approximately 1.5 CPU hours, it was more efficient to settle the question of a maximum shipping unit size by only considering the system up to the point where the items arrived at the pack stations and collect statistics up to that point. The results for 60-day runs of the modified simulation yielded the results in Tables 7 and 8 for goal and current workload scenarios respectively.

Table 6

PROCESSING TIMES-REVISED OFFER STATIONS

| Station | Average Processing Time |
|---|---|
| Offer Scan | 27.4 secs |
| Offer Label | 32.2 secs |
| Mode Label (UPS) | 17.0 secs |
| Mode Label (Small Parcel Air) | 24.6 secs |
| Mode Label (All others) | 138.8 secs |

Table 7

MAXIMUM SIZE SHIPPING UNIT SENSITIVITY-GOAL WORKLOAD
Average Daily Work in Multipack Chutes 1-8

| Max Size | Average Hours Work | % Times > 7 Hours |
|---|---|---|
| 100 | 3.7 | 0% |
| 150 | 4.6 | 4% |
| 200 | 5.2 | 17% |
| 250 | 5.6 | 32% |

Table 8

MAXIMUM SIZE SHIPPING UNIT SENSITIVITY-CURRENT WORKLOAD
Average Daily Work in Multipack Chutes 1-8

| Max Size | Average Hours Work | % Times > 7 Hours |
|---|---|---|
| 100 | 3.2 | 0% |
| 150 | 3.8 | 1% |
| 200 | 4.1 | 7% |
| 250 | 4.3 | 16% |

These indicate that if the goal is to ensure that only rarely does a packer get more than 7 hours of work then a cap of 150 should be placed on the size of the shipping unit. Of course there is a cost associated with this cap. A lower cap results in a reduction in the average amount of work each person performs in these first eight chutes. However, the low utilization in these chutes really does not present a problem since the packing supervisor can easily place them in the other chutes on days when they do not get a large shipping unit. This cap was placed on the shipping unit sizes for all subsequent simulation runs.

Next, we looked into the effects of the proposed changes in terms of the expected workload in each section. Since the only effect for the sections other than the offer station area would be to factor down the expected values presented in Table 3 previously by 25% (since workload has been reduced by 25% from 12,225 to 9,169) we concentrated on the offer station area. These are presented in Table 9 for the goal workload of 9,169.

Recall that the initial idea was to have a total of three scan stations-one between each of the two offer lines. From this table it is clear by examining the total hours work required that a single scan station placed between two single line offer stations would not suffice. This station would have to do two-thirds of the 16 hours of single scan work requirement. So one had to concede placing at least one scan per line on the upper two single offer lines.

Table 9

EXPECTED WORKLOAD-OFFER STATION RECONFIGURATION

| Function | Total Hours Work |
|---|---|
| Single Offer Scan | 16.0 |
| Multi Offer Scan | 7.9 |
| Multi Offer Label | 8.3 |
| Single Offer Label | 18.8 |
| Mode Label (UPS) | 2.2 |
| Mode Label (Small Parcel Air) | 1.5 |
| Mode Label (All Other) | 13.3 |

It appears from the expected value calculations that there also is some difficulty with the middle scan station servicing one single and one multi-offer station since its average workload is 8.1 hours. However, with the conveyor diverts prior to the offer area this would probably not present a real problem since work could be diverted to the multiline area.

When these results were discussed with the DOSO engineers it was decided to incorporate one scan station per offer line. This decision was based on several factors in addition to the results discussed above. One contributing factor was the fact that it would have required a software change to have the system identify which of the two lines the package being scanned was destined for. Another factor was that in view of the status of the installation and contract this alternative was the least disruptive and costly. Additional changes would also have to be made in the near future when the other increments (in particular small parcel costing) of DWASP would have to be accommodated.

Operating under this configuration in the offer area and with only 23 multiline packers and 8 single line packers (adjusted for the revised 9,169 goal workload) the system worked smoothly and easily met the goal workload in each of the areas. The reduction in single line packers actually eased up some of the queueing conditions in the single line offer area. With all 13 stations operating and with most of the single lines coming early in the day in the IPG 1s and 2s, an early surge hits the single line offer stations. This can also readily be seen from the processing times. Thirteen single line pack stations can pack at a rate of 428 per hour, while 3 single line offer stations can work only at a rate of 335 per hour. However, when the number of single line packers was reduced there was some concern about the length of time to finish the IPG 1s. Based on the simulation results the IPG 1s were completed within the first 2 hours of the day.

In the transportation mode label area we used one station for UPS and small parcel air and two for the remaining modes. The specific throughput, average queue sizes, and utilization rates that were produced by the model are presented in Table 10.

Table 10

SIMULATION RESULTS-OFFER STATION RECONFIGURATION
Average Daily Throughput, Queues, Utilization

| Section | Throughput | Queue Size* | Utilization |
| --- | --- | --- | --- |
| IRRD | 9,169 | 0 | 52% |
| Single Pack | 1,882 | 22 | 90% |
| Multi Pack | 7,287 | 18 | 70% |
| Offer Scan | 2,666 | 1 | 51% |
| Offer Label | 2,666 | 1 | 66% |
| Mode Label | 2,666 | 1 | 71% |

* Queue size is an average on a per chute or per station basis

Based on the above analysis, the conclusions and recommendations presented earlier were developed.

## APPENDIX A

## DDOU DWASP Simulation - Input Distributions

Table A-1

WORKSTATION PROCESSING TIMES

| Process | Time in Seconds |
|---|---|
| IRRD Regular | TRIAG(10.,10.5,11.)* |
| IRRD Exception | 13.0 - 3%<br>19.5 - 90%<br>120.0 - 7% |
| Single Pack | TRIAG(104.,109.,114.) |
| Multi Pack | TRIAG(62.,65.5,68.8) |
| Single Stitch | TRIAG(7.6,8.,8.4) |
| Single Dunnage | TRIAG(8.4,8.9,9.4) |
| Single Tape | TRIAG(10.5,11.,11.5) |
| Multi Dunnage | TRIAG(11.7,12.3,13.) |
| Offer (Orig config) | 30.2 - 39%<br>81.4 - 50%<br>178.2 - 11% |
| Offer Scan (Offer reconfig) | 17.0 - 39%<br>34.1 - 61% |
| Offer Label (Offer reconfig) | 17.3 - 39%<br>41.8 - 61% |
| UPS Label (Offer reconfig) | 17.0 |
| Small Parcel Air (reconfig) | 24.6 |
| Other Mode Label (reconfig) | 138.8 |

* TRIAG means triangular distribution

Table A-2

EQUIPMENT PROCESSING TIMES

| Equipment | Processing Time (Secs) |
| --- | --- |
| Computer Response | TRIAG(6.,8.,10.) |
| IRRD Printer | TRIAG(4.5,4.6,4.7) |
| Multi Seal | TRIAG(10.5,11.,11.5) |
| Multi Strap | TRIAG(7.7,16.,24.) |
| Route Slip & APL Printer | TRIAG(8.2,8.3,8.4) |
| MSL Printer | TRIAG(2.8,3.0,3.2)* |

* After interim briefing this was revised by adding one second

Table A-3

WORKFLOW BREAKOUTS

| | |
| --- | --- |
| Percentage to IRRD Exception | 7.5% |
| Percentage Multi Cartons Need Dunnage | 95.0% |
| Percentage Multi Cartons Need Seal | 100.0% |
| Percentage Multi Cartons Need Strap | 50.0% |
| Percentage Singles in Cartons | 77.5% |
| Percentage Single Cartons Need Dunnage | 99.0% |
| Percentage Single Cartons Need Taping | 100.0% |
| Percentage Single Bags Need Stitching | 100.0% |

Table A-4

MISCELLANEOUS INPUT DATA

| | |
|---|---|
| Average Number Cartons per Multi Shipping Unit | 1.28 |
| Average Number Cartons per Single Shipping Unit | 1.12 |
| Conveyor Speeds: | |
| Incline from Entry to IRRD Mezzanine | 60 feet/min |
| IRRD Mezzanine Conveyors | 120 feet/min |
| Tilt Tray Sorter | 185 feet/min |
| Packing Takeaway | 65 feet/min |
| Offer Area Conveyor | 120 feet/min |
| Offer Takeaway | 85 feet/min |

Table A-5

IPG1 and IPG2 Shipping Unit Distributions

IPG1
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AVG LINES PER DAY 802

AVG SU'S PER DAY 468

| SIZE | % OF SU'S |
|---|---|
| 1 | 78.13% |
| 2 | 10.48% |
| 3 | 4.31% |
| 4 | 2.00% |
| 5 | 1.35% |
| 6 | 0.88% |
| 7 | 0.46% |
| 8 | 0.44% |
| 9 | 0.26% |
| 10 | 0.31% |
| 11-15 | 0.74% |
| 16-20 | 0.23% |
| 21-25 | 0.15% |
| 26-30 | 0.07% |
| 31-50 | 0.13% |
| 51-70 | 0.05% |
| 71-90 | 0.01% |

SINGLES- 46% OF TOTAL LINES

IPG2
-----

AVG LINES PER DAY 802

AVG SU'S PER DAY 468

| SIZE | % OF SU'S |
|---|---|
| 1 | 72.81% |
| 2 | 12.66% |
| 3 | 5.03% |
| 4 | 2.85% |
| 5 | 1.67% |
| 6 | 1.13% |
| 7 | 0.62% |
| 8 | 0.43% |
| 9 | 0.40% |
| 10 | 0.28% |
| 11-15 | 0.79% |
| 16-20 | 0.36% |
| 21-30 | 0.38% |
| 31-40 | 0.17% |
| 41-60 | 0.16% |
| 61-80 | 0.08% |
| 81-100 | 0.04% |
| 101-150 | 0.10% |
| 151-200 | 0.02% |
| 201-1000 | 0.00% |
| 1000-1500 | 0.02% |

SINGLES-29% OF TOTAL LINES

Table A-6

IPG3 Shipping Unit Distribution

| IPG3-BATCH 1 | | IPG3-BATCH 2 | |
|---|---|---|---|
| AVG LINES PER DAY | 2522 | AVG LINES PER DAY | 1925 |
| AVG SU'S PER DAY | 103 | AVG SU'S PER DAY | 895 |
| SIZE | % OF SU'S | SIZE | % OF SU'S |
| 1 | 38.62% | 1 | 62.33% |
| 2 | 4.93% | 2 | 15.83% |
| 3 | 2.81% | 3 | 7.23% |
| 4 | 1.43% | 4 | 4.07% |
| 5 | 1.26% | 5 | 2.85% |
| 6 | 0.63% | 6 | 2.03% |
| 7 | 0.86% | 7 | 1.41% |
| 8 | 0.06% | 8 | 1.30% |
| 9 | 0.57% | 9 | 0.91% |
| 10 | 0.40% | 10 | 0.60% |
| 11-15 | 9.46% | 11-15 | 1.31% |
| 16-20 | 9.28% | 16-20 | 0.09% |
| 21-30 | 10.72% | 21-30 | 0.02% |
| 31-40 | 5.39% | 31-40 | 0.01% |
| 41-60 | 5.79% | 41-60 | 0.00% |
| 61-80 | 2.35% | 61-80 | 0.00% |
| 81-100 | 1.32% | 81-100 | 0.00% |
| 101-150 | 1.60% | 101-150 | 0.00% |
| 151-200 | 0.74% | 151-200 | 0.01% |
| 201-500 | 1.43% | 201-500 | 0.01% |
| 501-1000 | 0.34% | 501-1000 | 0.00% |

SINGLES WERE 1.57% OF TOTAL LINES    SINGLES WERE 29% OF TOTAL LINES